



## Photocatalytic/Magnetic Composite Particles

**Magnetic agitation enhances effectiveness.**

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Photocatalytic/magnetic composite particles have been invented as improved means of exploiting established methods of photocatalysis for removal of chemical and biological pollutants from air and water. The photocatalytic components of the composite particles

are formulated for high levels of photocatalytic activity, while the magnetic components make it possible to control the movements of the particles through the application of magnetic fields. The combination of photocatalytic and magnetic properties can be exploited in designing improved air- and water-treatment reactors.

A typical composite particle according to the invention (see Figure 1) includes a magnetic substrate or core particle having a size of the order of 100  $\mu\text{m}$ , a layer to protect the core against chemical attack, and an outer coat of nano-sized photocatalyst particles on the protective layer. In an application in which the protective layer is not needed, it can

be omitted and the photocatalyst particles coated directly onto the core. Another option is to make the core of a nonmagnetic material and to coat it with nano-sized photocatalyst and magnetic particles.

As used here, “nano-sized” refers to sizes in the range from a few nanometers to about 100 nanometers. The reason for choosing this size range is simply that experience has shown that nano-sized photocatalyst particles are more photocatalytically active than are micron- and larger-sized photocatalyst particles.

The magnetic core (or, optionally, the nano-sized magnetic particles) can be made of any of a variety of suitable magnetic materials — for example,  $\text{Fe}_3\text{O}_4$ ,

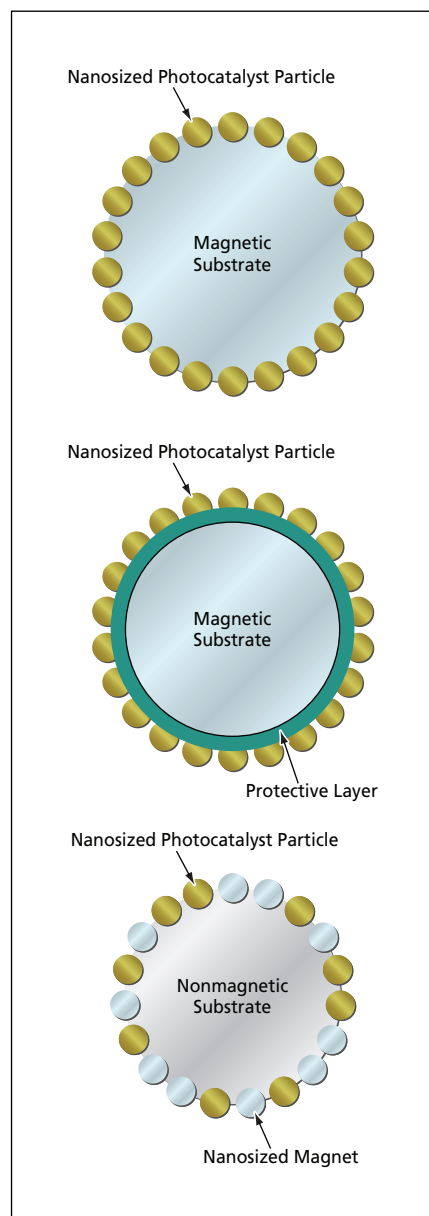


Figure 1. **Photocatalytic/Magnetic Composite Particles** according to the invention can be made in different forms.

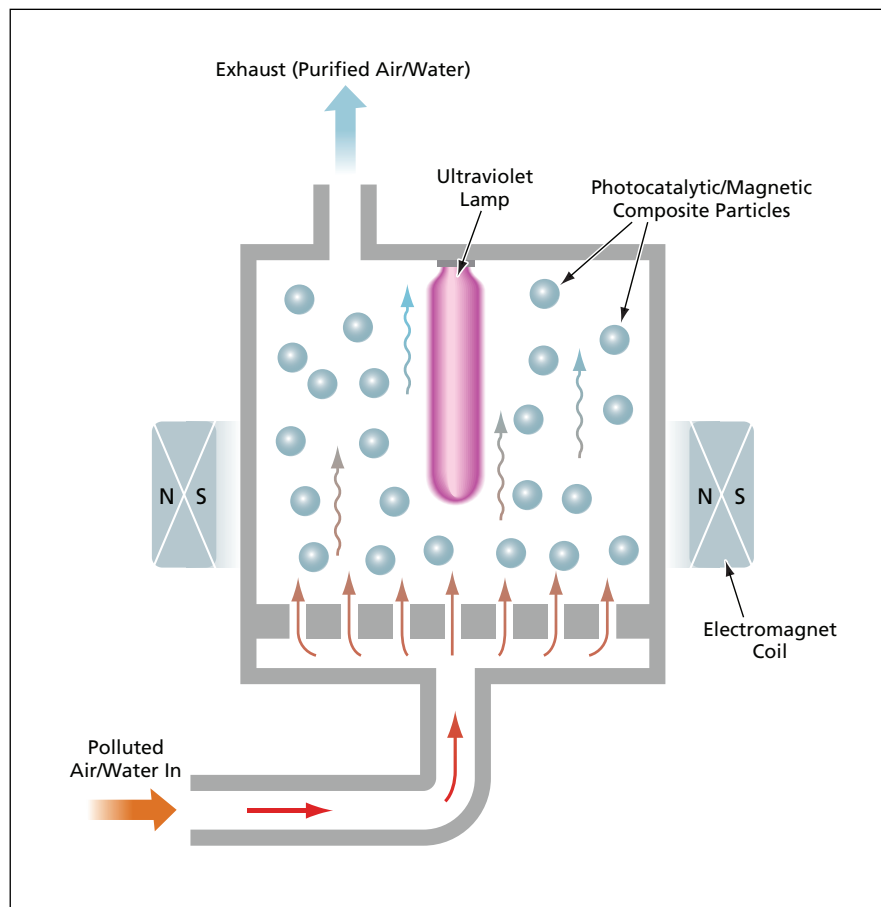


Figure 2. A **Fluidized Bed** containing photocatalytic/magnetic composite particles is illuminated by ultraviolet light. The bed is agitated by the flow of polluted air to be treated and by an alternating magnetic field.

BaO(Fe<sub>2</sub>O<sub>3</sub>)<sub>6</sub>, SrO(Fe<sub>2</sub>O<sub>3</sub>)<sub>6</sub>, or AlNiCo. The protective layer can be a polymer or a ceramic — for example, poly(tetraethylfluoroethylene) or poly(methyl methacrylate) or silica. The photocatalyst can be TiO<sub>2</sub>, ZnO, or Fe<sub>2</sub>O<sub>3</sub>. Nano-sized photocatalyst particles can be coated onto the larger core particles by various techniques, e.g., a dry coating machine, wherein a mixture of the two types of particles is forced to pass through a narrow clearance under high stress.

A representative reactor for treatment of air by use of photocatalytic/magnetic composite particles (see Figure 2) includes a fluidized bed loaded with the particles. An ultraviolet lamp provides the excitatory photons needed for photocatalysis. An electromagnet coil generates

a magnetic field to control the movement of the composite particles.

In operation, polluted air or water enters at the bottom and flows upward through the fluidized bed. The polluted fluid agitates, and mixes with, the composite particles in the bed. Additional agitation is provided by an alternating magnetic field generated by supplying alternating current to the electromagnet coil. The agitation enhances the fluidization, and is almost entirely responsible for fluidization when the flow is not rapid enough to fluidize the particles sufficiently. The agitation promotes the exposure of the photocatalyst particles to ultraviolet light from the lamp and increases the rate of generation of hydroxyl radicals, which react with the pollutants. The

exhaust flowing from the top of the reactor consists of purified fluid.

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